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AN EXPERIMENTAL STUDY ON MATHEMATICAL MODELLING OF OSMOTIC DEHYDRATION OF BEETROOT

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ABSTRACT

Osmotic Dehydration of beetroot was conducted by using three concentration levels (40, 50 and 60 %) of osmotic agents such as sucrose, fructose and maltodextrin along with three salt concentrations (5, 10 and 15 %) were used at three different levels of osmotic solution temperature (40, 50 and 60 °C). The samples to solution ratio were taken at three levels, i.e., 1:4, 1:5 and 1:6 for all the experiments. The full factorial design was employed to determine the number of experiments for osmotic dehydration. Osmotic solutions were prepared by dissolving the different levels of sucrose, fructose and maltodextrin along with NaCl in distilled water (w/w). A magnetic stirrer was used to dissolve the contents. The fresh osmotic solution was prepared for every run. The surface moisture was removed by using blotting paper. Osmotic dehydration was carried out from 10 to 240 min with varying time intervals to investigate the osmotic kinetics at each experimental condition. The moisture loss and solid gain were computed on the basis of mass balance. Models for dependent parameters of osmotic dehydration process, i.e., moisture loss and solid gain of beet-root were developed in terms of independent parameters (temperature, concentration of agents, sample to solution ratio and time of osmosis) using a scrambler software (CAMO AS, Trondheim, Norway, version 8.0.5). For the osmotic dehydration of beetroot total six best fitted models were developed by using 972 samples experimented with respect to different experimental conditions (time, solution temperature, osmotic treatments, sample to solution ratio and binary solution concentrations). The models for moisture loss and solid gain were developed and validated on the basis of the high value of the coefficient of correlation (r). In addition, the low value of SEC (standard error of calibration) and SEP (standard error of prediction) and insignificant biases in calibration and validation models indicated that the models for determining moisture loss and solid gain during osmotic dehydration of beetroot samples in different osmotic agents are best fitted to the data.

KEYWORDS: Surface Moisture was Removed by Using Blotting Paper, Models for Moisture Loss & The Low Value of SEC

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Original Article

INTRODUCTION

Beta vulgaris, commonly known as beetroot or beet, which is a flowering plant species in the family of Chenopodiaceous. Several cultivars are valued around the world, as edible root vegetables, fodder (*Mangel*) and sugar producing beet. It is grown widely in Germany and France and in lesser amounts in other European countries, Africa, Asia, and South America. Beetroot is now a popular salad vegetable. Beetroot can be peeled, steamed, and then eaten warm with butter as a delicacy; cooked, pickled, and then eaten cold as a condiment; or peeled, shredded raw, and then eaten as a salad. One increasingly popular preparation involves tossing peeled and diced beets with a

small amount of oil and seasoning, then roasting in the oven until tender. Garden beet juice is a popular health food (Manivannan and Rajasimman 2008). Betanins, obtained from the roots, are used industrially as red food colorants, e.g. to improve the colour of tomato paste, sauces, desserts, jams and jellies, ice cream, sweets and cereals.

Since ancient time, dehydration has been one of the most common natural and reliable methods for food preservation. Although reaction rates are generally reduced by dehydration, undesirable changes due to reactions such as enzymatic browning may result in quality changes (Acker, 1969; Kouassi and Roos 2001). Sugar, honey and salt have been used as aids in the drying of fruits and vegetables at various times in the past (Goldblith 1972; Wood roof 1986).

Osmotic dehydration is a water removal process involving soaking foods, mostly fruits and vegetables, in a hypertonic solution such as a concentrated brine solution. Two major simultaneous counter-current flows occur during osmotic dehydration: and important water flow out of the food into the solution and a simultaneous transfer of solute from the solution into the food (Madamba, 2003). Osmotic dehydration is used as a pre-treatment for many processes used to improve nutrition, sensorial and functional properties of food without changing its integrity. (Torrengiani, 1993). It generally precedes process such as freezing, freeze-drying, vacuum drying or air-drying. It also increases sugar to acid ratio, and improves texture and stability of pigments during dehydration and storage. It is effective around ambient temperatures, so heat damage to texture; colour and flavor can be minimized. The other major application is to reduce the water activity of food materials so that microbial growth will be inhibited. (Raoult-Wack, 1994). Since most food materials contain large amount of water, they are cost intensive to ship, pack and store. Osmotic dehydration is acknowledged to be an energy efficient method of partial dehydration, since there is no need for a phase change.

In light of above discussion the main objective of this work is to develop the mathematical model for osmotic dehydration of beetroot in sucrose, maltodextrin and fructose of different concentration with NaCl solution at different temperature solutions with different sample to solution ratio.

MATERIALS AND METHODS

Osmotic solutions were prepared by dissolving the different levels of sucrose, fructose and maltodextrin along with NaCl in the distilled water (w/w) for beetroot. A magnetic stirrer was used to dissolve the contents. An electronic balance with 0.001 g least count was used to weigh the sucrose, fructose, maltodextrin and NaCl. The fresh osmotic solution was prepared for every run. Properly matured and dark red beetroot was selected for the purpose. Beetroots should not have blemish on surface or any mechanical damage. Damaged Beetroot may lead to contamination. Beetroots was properly washed and cleaned under tap water by thoroughly washing. The peeling was done around 1 mm deep. Care had been taken that more deep peeling should avoid decreasing waste. After peeling again Beetroots was washed. The Beetroots was sliced in 40 mm x 20 mm x 4 mm dimension for blanching and further process. The main purpose of slicing was to give beetroot a uniform shape and size throughout the experiment. The purpose of blanching is to inactivate the enzyme present in food commodity. Time and temperature combination for blanching of beetroot is 100 °C for 5 minutes. The pieces were then removed from the water and, there surfaces gently blotted with absorbent paper (Lenart and Flink, 1984). The sample was then used for osmosis and initial moisture content determination.

A flask shaker was used for the osmotic dehydration. The temperature and agitation were controlled during the overall osmotic dehydration time. During osmotic dehydration twelve 500 ml beakers were filled with an osmotic solution having a sample to solution ratio 1:4, 1:5 and 1:6. The prepared 30 g beetroot samples were immersed in each beaker. One

beaker at times taken out from the shaker after 10, 20, 30, 40, 50, 60, 90, 120, 150, 180, 210 and 240 min from the beginning of osmosis. Based on the preliminary experiments and review of literature three concentration levels (40, 50 & 60 %) of sucrose, fructose and maltodextrin with Nacl (5, 10 &15 %) were used at temperature levels (40, 50 & 60 ^{0}C) (Grabowski et al. 1994; Welti et al. 1995; Ertekin and Cakaloz 1996; Sagar, 2001). During all experiments, the solution was agitated constantly at 100 rounds per minute. After each time period of osmosis, slices were removed carefully by draining off solution and dipped in distilled water and were shaken manually for short time at room temperature to rinse out osmotic agent from the surface. Free surface moisture was removed with tissue paper by gently pressing and weighed on an electronic balance.

The initial and final moisture content of the sample was determined by using hot air oven method recommended by Ranganna (2001) for fruits and vegetables.

$$MC(\%wb) = \frac{(W + W_1) - W_2}{W} * 100$$

Where W= Net weight of sample taken (g)

W_1= Weight of dish (g)

W_2= Weight of dish plus oven dried sample (g)

The moisture loss (ML) % was measured by the following equation suggested by (Lenart and Flink, 1994: Hawkes and Flink, 1978).

$$ML(\%) = \frac{M_0 - M}{W} * 100$$

Where M_0 =Wt of initial moisture (g)

M = Wt of final moisture (g)

W = Initial wt of sample (g)

The solid gain (SG) % was measured by the following equation suggested by (Lenart and Flink, 1994: Hawkes and Flink, 1978).

$$SG(\%) = \frac{S - S_0}{W} * 100$$

Where S =Wt of final solid (g) S_0 = Wt of initial solid (g)

The models were developed for osmotic dehydration process of beetroot. Models for dependent parameter of osmotic dehydration process moisture loss and solid gain of beetroot were developed in terms of the independent parameter (temperature, concentration of agents, sample to solution ratio and time of osmosis) using a scrambler software (CAMO AS, Trondheim, Norway, version 8.0.5). In this the multi linear regression method was used to develop the quadratic model for moisture loss and solid gain during osmotic dehydration of beetroot. Total six best fitted models were developed by using 972 runs with respect to different experimental conditions (time, solution temperature, osmotic treatments, sample to solution ratio and binary solution concentrations).

The mathematical model for beetroot, the moisture loss and solid gain for different osmotic agents with Nacl is

represented as

$$ML = a\,T + b\,C + c\,S_c + d\,S_r + e\,t + f\,TC + g\,TS_c + h\,CS_c + i\,T^2 + j\,C^2 + k\,S_c^2 + l$$

$$SG = a\,T + b\,C + c\,S_c + d\,S_r + e\,t + f\,TC + g\,TS_c + h\,CS_c + i\,T^2 + j\,C^2 + k\,S_c^2 + l$$

Where, a, b, c, d, e, f, g, h I, j, k and l are the coefficient, T is the temperature of osmotic dehydration in °C, C is the concentration of osmotic agents solution in percentage, Sc is the concentration of salt in percentage, S_r is the sample to solution ratio in percentage, it is the osmotic dehydration time in min.

Full cross validation method was used to validate or simulate the data. Full cross validation leaves out only one sample at a time and this sample was used for the validation of model at that time. In this method of validation the model was validated by each data.

RESULTS AND DISCUSSIONS

Several mathematical models were developed for osmotic dehydration of beetroot before selecting the best model. As illustrated above, the multi linear regression method was used for this purpose, and developed models for moisture loss and solid gain during osmotic dehydration of beetroot. In this modeling process of osmotic dehydration of beetroot total 972 runs were experimented with respect to different experimental conditions (time, solution temperature, osmotic treatments, and sample to solution ratio and solution concentrations) for the development of models. Full cross validation method was used to validate or simulate the data. Six best models (three for the moisture loss and three for solid gain) in three different osmotic agents such as sucrose, fructose and maltodextrin, along with NaCl were developed and reported in this study.

MLR Models for Determining Moisture Loss during Osmotic Dehydration of Beetroot Samples in Different Osmotic Agents

For the calculation of moisture loss of beetroot during osmotic dehydration three models (one each for sucrose, fructose and maltodextrin osmotic agents) were suggested based on temperature, time, NaCl concentration and osmotic agent. The high value of the coefficient of correlation (0.930 to 0.932) of the calibration models and low value of the SEC / SEP either it based on sucrose, fructose or maltodextrin suggests that the data are best fitted (Table 1).

Similarly, for the validation models, all statistical results were found satisfactory. Among these, the standard error of the validation model based on sucrose was lowest and followed by fructose and then by maltodextrin. However, the correlation coefficient of the validation model based on fructose (r= 0.937) was a little higher than the sucrose and maltodextrin based validation model (r=0.935).

In addition, the bias in calibration and validation models based on sucrose, fructose or maltodextrin osmotic agents was founded insignificant, also suggested that the models, reported below, are the best models for the determination of moisture loss.

$$ML(\text{in sucrose}) = 0.161\mathrm{T} + 0.128\mathrm{C_s} + 7.62\times10^{-2}\mathrm{S_c} + 5.88\times10^{-2}\mathrm{S_r} + 0.144\mathrm{t} + 2.6\times10^{-6}\,\mathrm{TC_s} - 9.08\times10^{-6}\mathrm{TS_c} - 1.63\times10^{-6}\,\mathrm{C_sS_c} - 3.45\times10^{-5}\mathrm{T}^2 - 3.83\times10^{-5}\mathrm{C_s^2} - 1.18\times10^{-4}\mathrm{S_c^2} - 4.208$$

$$ML\text{ (in maltodextrin)} = 0.198\mathrm{T} + 0.183\mathrm{C_M} + 6.35\times10^{-2}\mathrm{S_c} + 5.87\times10^{-2}\mathrm{S_r} + 0.145\mathrm{t} + 4.89\times10^{-5}\,\mathrm{TC_M} + 5.69\times10^{-5}\mathrm{TS_c} + 2.50\times10^{-5}\,\mathrm{C_M S_c} + 6.43\times10^{-5}\mathrm{T}^2 - 5.06\times10^{-4}\mathrm{C_M}^2 + 2.63\times10^{-4}\mathrm{S_c^2} - 6.869$$

$$ML\text{(in fructose)} = 0.226\mathrm{T} + 0.164\mathrm{C_F} + 7.32\times10^{-2}\mathrm{S_c} + 5.85\times10^{-2}\mathrm{S_r} + 0.145\mathrm{t} - 6.33\times10^{-5}\,\mathrm{TC_F} + 7.15\times10^{-6}\mathrm{TS_c} + 4.89\times10^{-5}\,\mathrm{C_F S_c} - 1.44\times10^{-6}\mathrm{T}^2 - 3.81\times10^{-5}\mathrm{C_F}^2 - 1.54\times10^{-4}\mathrm{S_c^2} - 7.39$$

Furthermore, better prediction of the moisture loss model of beet-root for sucrose, maltodextrin and fructose is illustrated in scatter plots of actual moisture loss (%) verses predicted moisture loss (%) for calibration and validation sample sets in Figure 1- Figure 6.

MLR Models for Determining Solid Gain during Osmotic Dehydration of Beetroot Samples in Different Osmotic Agents

Three MLR models (one for each osmotic agent), among the best fitted models developed for determining the solid gain during osmotic dehydration of beetroot are selected and given below:

$$SG\text{(in sucrose)} = 1.45\times10^{-2}\mathrm{T} + 1.44\times10^{-2}\mathrm{C_s} + 1.39\times10^{-2}\mathrm{S_c} + 1.55\times10^{-2}\mathrm{S_r} + 2.02\times10^{-2}\mathrm{t} + 2.97\times10^{-6}\,\mathrm{TC_s} - 2.14\times10^{-5}\mathrm{TS_c} - 1.87\times10^{-5}\,\mathrm{C_s S_c} + 2.14\times10^{-5}\mathrm{T}^2 + 2.18\times10^{-5}\mathrm{C_s^2} + 6.67\times10^{-5}\mathrm{S_c^2} + 0.119$$

$$SG\text{ (in maltodextrin)} = 4.36\times10^{-2}\mathrm{T} + 7.64\times10^{-2}\mathrm{C_M} + 1.38\times10^{-2}\mathrm{S_c} + 1.57\times10^{-2}\mathrm{S_r} + 2.05\times10^{-2}\mathrm{t} + 1.27\times10^{-5}\,\mathrm{TC_M} + 2.97\times10^{-6}\mathrm{TS_c} - 1.05\times10^{-5}\,\mathrm{C_M S_c} - 1.08\times10^{-4}\mathrm{T}^2 - 4.89\times10^{-4}\mathrm{C_M}^2 - 1.58\times10^{-5}\mathrm{S_c^2} - 2.341$$

$$SG\text{(in fructose)} = 7.64\times10^{-3}\,\mathrm{T} + 3.67\times10^{-2}\mathrm{C_F} - 1.92\times10^{-3}\mathrm{S_c} + 1.57\times10^{-2}\mathrm{S_r} + 2.04\times10^{-2}\mathrm{t} + 4.79\times10^{-5}\,\mathrm{TC_F} + 5.05\times10^{-5}\mathrm{TS_c} + 1.71\times10^{-4}\mathrm{C_F S_c} + 2.27\times10^{-4}\mathrm{T}^2 - 6.56\times10^{-5}\mathrm{C_F}^2 - 1.74\times10^{-4}\mathrm{S_c^2} - 0.517$$

These models were selected on the basis of their statistical results. The low value of the standard error in calibration (SEC) and prediction (SEP), insignificant bias for calibration and validation, and high value of the coefficient of correlation for both calibration and validation models were the basis of selection of the best models for determining solid gain during osmotic dehydration of beet-root samples in different osmotic agents (Table 2). The standard error of calibration models varies between 0.575-0.596. The SEC/SEP was found minimum for the model based on sucrose osmotic agent, while the maximum was for the model, based on maltodextrin. Further, the correlation coefficient of calibration was maximum for fructose based model (r = 0.939) while for sucrose and maltodextrin based calibration model the correlation coefficient was found same (r=0.937).

Similarly, the standard error of validation was also minimum for solid gain model, based on sucrose and maximum for solid gain model, based on maltodextrin. In addition, the maximum coefficient of correlation (r) was obtained for the validation model based on fructose i.e. 0.937. However, the coefficient of correlation (r) for the calibration models based on sucrose and maltodextrin model was same i.e. 0.935. Furthermore, for the purpose of good prediction of the solid gain model of beetroot for three osmotic agents (sucrose, maltodextrin and fructose) are illustrated in scatter plots of actual solid gain (%) verses predicted solid gain (%) for calibration and validation sample sets in Figure 7- Figure 12.

CONCLUSIONS

For osmotic dehydration of beetroot samples six best fitted models were developed by 972 runs with different experimental conditions. Out of six models three for the moisture loss based on three different osmotic agents and rest three models for computing the solid gain in case of three different osmotic agents (sucrose, fructose and maltodextrin). The models for moisture loss and solid gain were developed and found best on the basis of the coefficient of correlation (r) value. In addition, the low value of SEC (standard error of calibration) / SEP (standard error of prediction), insignificant biases in the calibration and validation models were also indicated that the models for determining moisture loss and solid gain during osmotic dehydration of beetroot samples in different osmotic agents are best fitted to the data.

REFERENCES

1. *Acker L (1969) The practical approaches to better low moisture foods: water activity-enzyme activity. Food Technol. 23: 1257-1259.*
2. *Changrue V.,Orsat V.,G.S.V. Raghavan G.S.V.,D. Lyew D.(2008) Effect of osmotic dehydration on the dielectric properties of carrots and strawberries, Journal of Food Engineering, Volume 88, Issue 2, Pages 280-286.*
3. *Ertekin F K, Cakalo Z T (1996) Osmotic dehydration of peas: Influence of process variables on mass transfer, Journal of Food Processing and Preservation, 20: 87-95.*
4. *G. Woodroof, J. (1986). History and Growth of Fruit Processing. 1-24. 10.1007/978-94-011-7385-8_1.*
5. *Gani Gousia, Kumar Avanish (2013) Effect of Drying Temperature and Microwave Power on the Physico-Chemical Characteristics of OsmoDehydrated Carrot Slices International Journal of Scientific and Research Publications, Volume 3, Issue 11, ISSN 2250-3153.*
6. *Kulwinder Kaur & A K Singh, Mathematical Modelling of Mass Transfer for Osmotic Dehydration of Beetroot (Beta vulgaris L.), International Journal of Agricultural Science and Research(IJASR), Volume 3, Issue 4, October 2013, pp. 1-10*
7. *Goldblith S A (1972) Science and technology in thermal processing. Part 2. Food Technol. 26: 64-69.*
8. *Grabowski S, Mujuumdar AS, Ramaswamy HS and Strumillo C (1994) Osmo-convective drying of grapes, Drying Technol, 12(5): 1211-1219.*
9. *Hawakes J, Flink J M (1978) Osmotic concentration of fruit slices prior to freeze dehydration. Journal of food processing and preservation Vol. 2:265-283.*
10. *Jha S.N.,Chopra Sangeeta, Kingsly A.R.P. (2007) Modeling of color values for nondestructive evaluation of maturity of mango, Journal of Food Engineering, Volume 78, Issue 1, Pages 22-26.*
11. *Khana M. Ali,Shuklaa R. N.,Zaidib Sadaf (2011)Mass Transfer during Osmotic dehydration of Apple using Sucrose, Fructose and Maltodextrin Solution, Published in the Proceedings of 11th International Congress on Engineering.*
12. *Kouassi K, Roos H Y (2001) Glass transition and water effects on sucrose inversion in noncrystalline carbohydrate food systems. Food Res. Int. 34: 895-901.*
13. *Lenart A, Flink J M (1984) Osmotic dehydration of potato. Journal of food technology, 19, 65-89.*
14. *Madamba P. S. (2003). Thin layer drying models for osmotically predried young coconut, Drying Technology, vol.21, 2003, pp. 1759-1780*
15. *Manivannan P and Rajasimman M. (2008)Osmotic Dehydration of Beetroot in Salt Solution: Optimization of Parameters*

through Statistical Experimental Design,International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering Vol:2, No:1.

16. *Manivannan P, Rajasimman M, (2008) Osmotic Dehydration of Beetroot in Salt Solution: Optimization of Parameters through Statistical Experimental Design. International Journal of Chemical and Biological Engineering 1:4 2008, pp. 214-221.*
17. *Ranganna S (2001) Handbook of Analysis and Quality control of Fruit and Vegetable Products, 2nd Ed., Tata McGraw-Hill Publ.Co., New Delhi.*
18. *RaoultWack A L (1994) Recent advances of osmotic dehydration of foods. Journal of trends in food sci. technol., 5: 255-260.*
19. *Sagar V R (2001) Preparation of onion powder by means of osmotic dehydration and its packaging and storage, Journal of Food Science Technol, 38(5):525-528.*
20. *Rama Nath and Gawande H. A. (2014)Microwave drying of osmotically dehydrated beet root, Scholarly Journal of Engineering Research Vol. x(x), pp. xxx-xxx.*
21. *Singh Ela, Kalyani B.,Reddy B.Shashank,Kalyani P. Ushasri,Devi V. Harika,Ravi L., Shanti M. (2015)Study On dehydration of Papaya Slices Using Osmotic Dehydration Mediated Hot Air Oven Drying, IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 9, Issue 11 Ve, PP 72-95.*
22. *Torreggiani D (1993) Osmotic dehydration of fruits and vegetable processing. Fd. Res. Int., 26: 59-68.*
23. *USDA Nutrient Database,schools-wikipedia.org/wp/b/Beet.htm.*
24. *Vannan, Mani & Manivasagan, Rajasimman. (2008). Osmotic Dehydration of Beetroot in SaltSolution: Optimization of Parameters throughStatistical Experimental Design. International Journal of Chemical and Biological Engineering. 1.*
25. *Welti J, Palou E, Lopez-Malo A, Balseira A (1995) Osmotic concentration-drying of mango slices. Drying Tecnhol. 13 (1&2): 405*
26. *Woodroof J G (1986) History and growth of fruit processing. In: Commercial fruit processing. Woodroof J G, LuhSHiun B (Eds.) (2nded). AVI Publishing Company Inc., Westport, Connecticut, USA. 1-24.*
27. *Wu Yan-Wen,Sun Su-Qin, Zhou Qun,Leung Hei-Wun (2008) Fourier transform mid-infrared (MIR) and near-infrared (NIR) spectroscopy for rapid quality assessment of Chinese medicine preparation Honghua Oil, Journal of Pharmaceutical and Biomedical Analysis,Volume 46, Issue 3, 13 Pages 498-504.*
28. *Zahoor I, Khan MA (2017) Mass Transfer Kinetics of Osmotic Dehydration of Pineapple. J Food Process Technol 8:653. doi: 10.4172/2157- 7110.1000653.*

Table 1: Statistical Results of MLR Models for Determining Moisture Loss during Osmotic Dehydration of Beetroot Samples in Different Osmotic Agents

Model for Different Agents	SEC/SEP		Bias		Correlation	
	Calibration	Validation	Calibration	Validation	Calibration	Validation
Sucrose	4.352	4.407	-0.000	0.004	0.93	0.928
Maltodextrin	4.38	4.436	0.000	0.004	0.93	0.928
Fructose	4.348	4.403	-0.000	0.004	0.932	0.93

Table 2: Statistical Results of MLR Models for Determining Solid Gain during Osmotic Dehydration of Beetroot Samples in Different Osmotic Agents

Model for Different Agents	SEC/SEP		Bias		Correlation	
	Calibration	Validation	Calibration	Validation	Calibration	Validation
Sucrose	0.575	0.583	0.000	0.001	0.937	0.935

Table 2: Contd.,						
Maltodextrin	0.596	0.603	0.000	0.001	0.937	0.935
Fructose	0.583	0.591	0.000	0.001	0.939	0.937

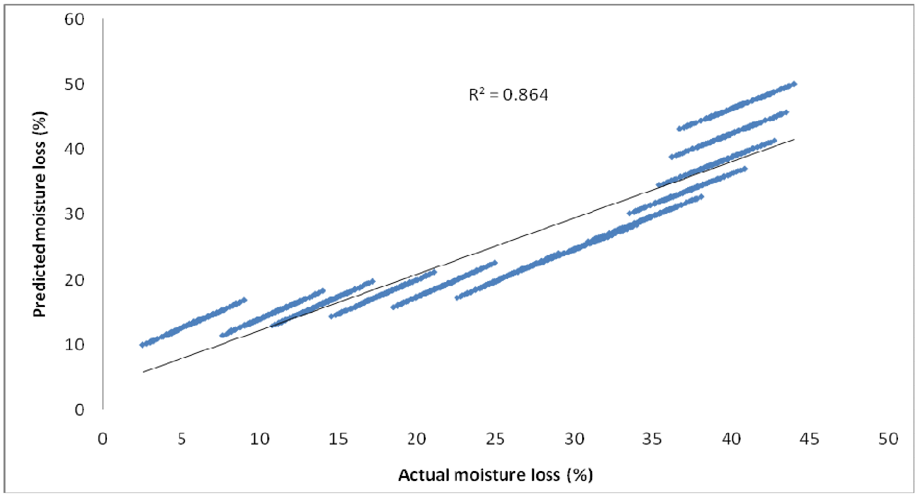

Figure 1: Actual Versus Predicted Moisture Loss of Beetroot in Sucrose of Calibration Sample Set

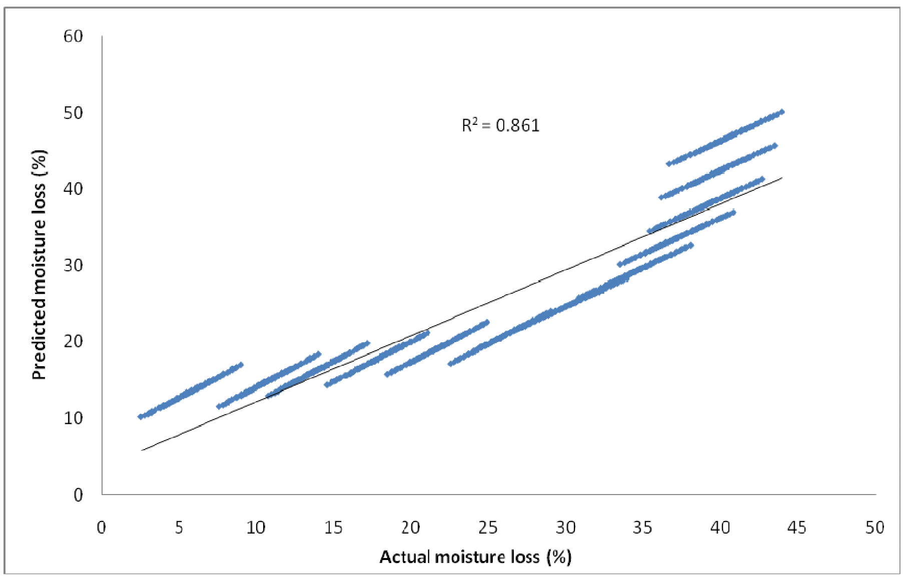

Figure 2: Actual Versus Predicted Moisture Loss of Beetroot in Sucrose of Validation Sample Set

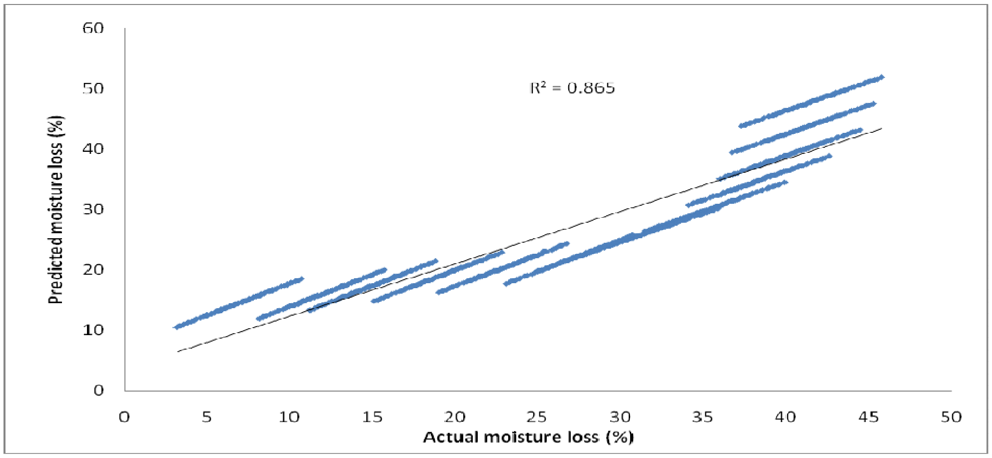

Figure 3: Actual Versus Predicted Moisture Loss of Beetroot in Maltodextrin of Calibration Sample Set

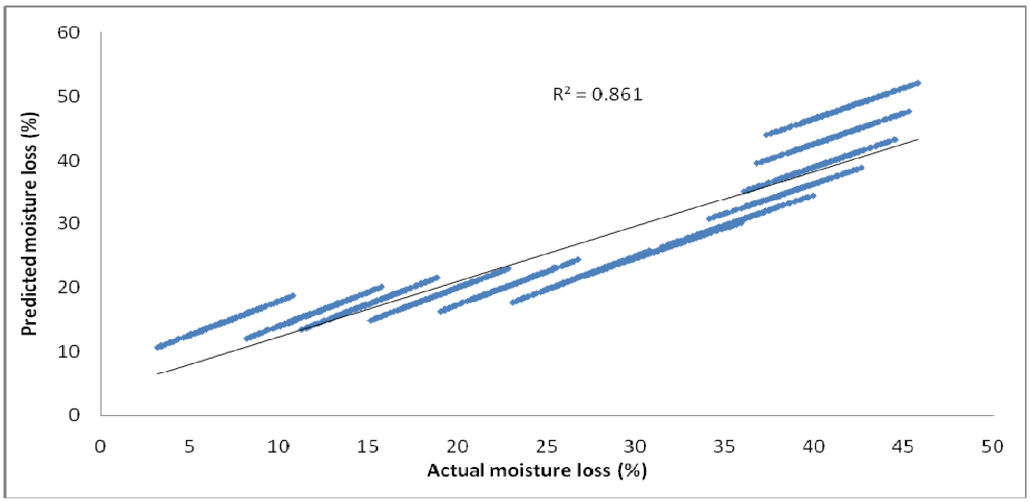

Figure 4: Actual Versus Predicted Moisture Loss of Beetroot in Maltodextrin of Validation Sample Set

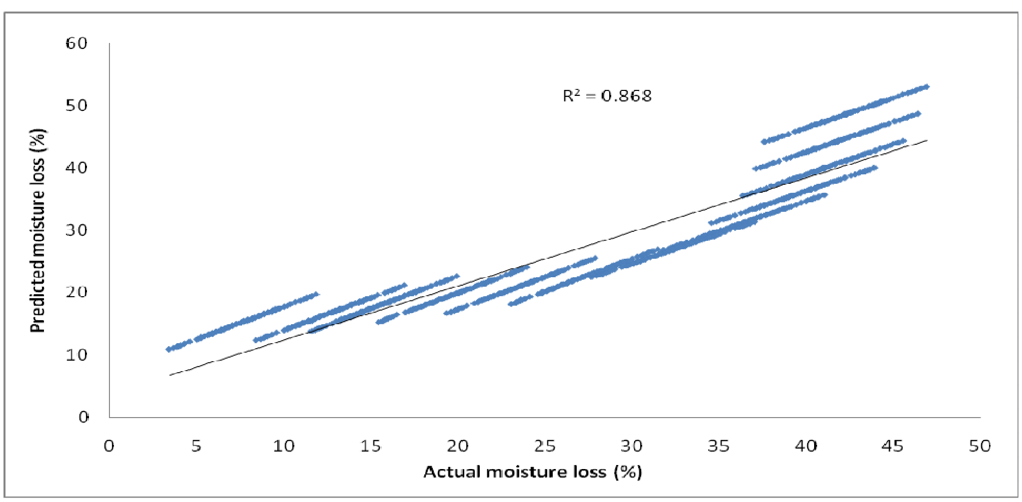

Figure 5: Actual Versus Predicted Moisture Loss of Beetroot in Fructose of Calibration Sample Set

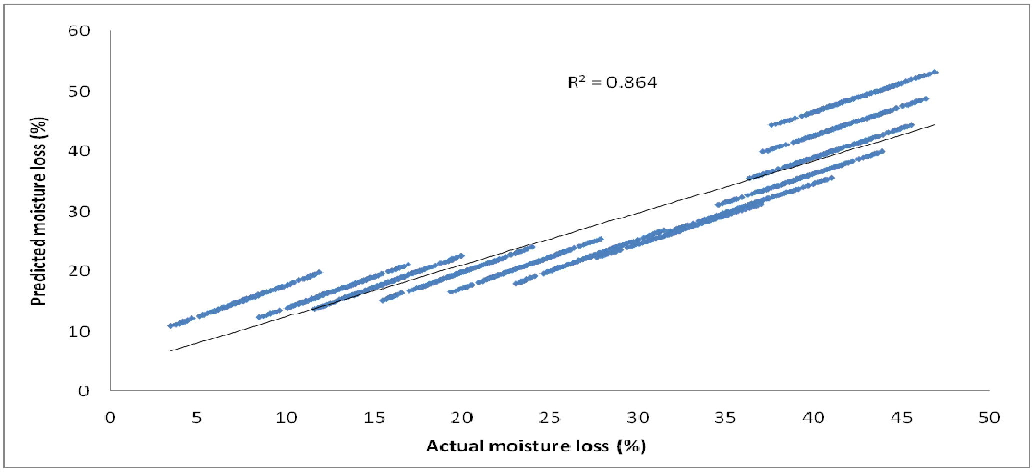

Figure 6: Actual Versus Predicted Moisture Loss of Beetroot in Fructose of Validation Sample Set

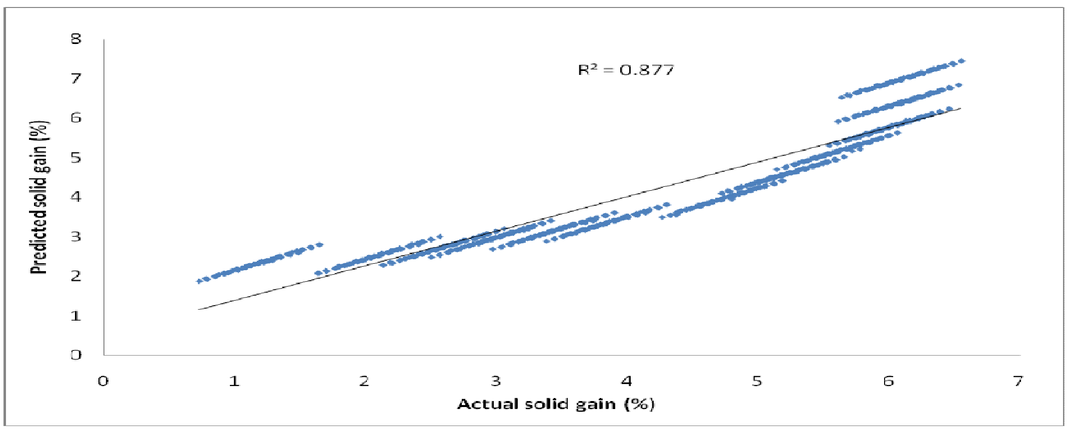

Figure 7: Actual Versus Predicted Solid Gain of Beetroot in Sucrose of Calibration Sample Set

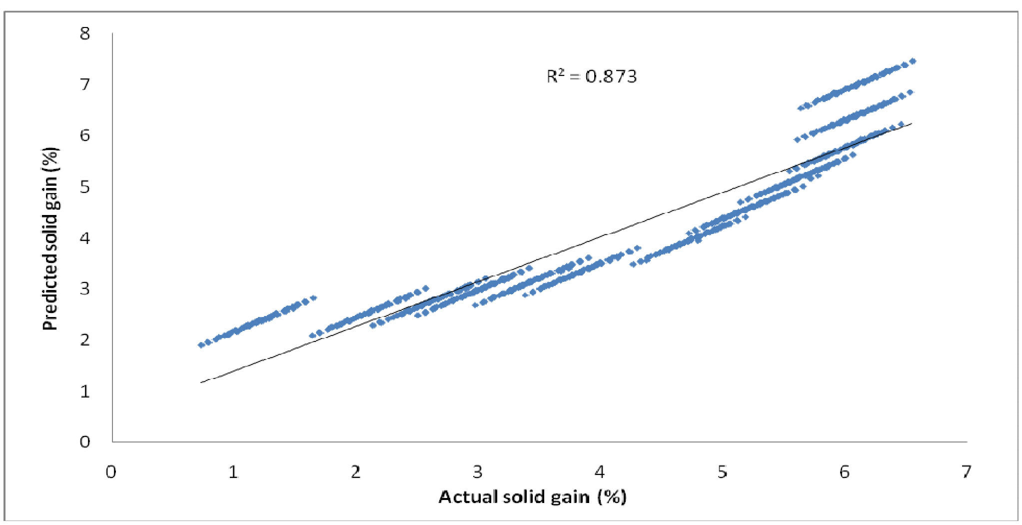

Figure 8: Actual Versus Predicted Solid Gain of Beetroot in Sucrose of Validation Sample Set

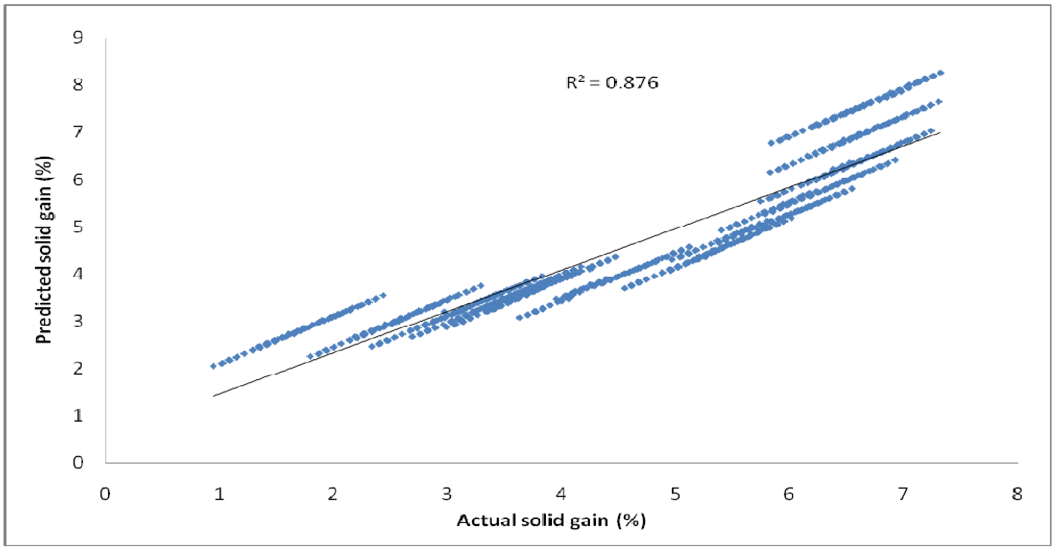

Figure 9: Actual Versus Predicted Solid Gain of Beetroot in Maltodextrin of Calibration Sample Set

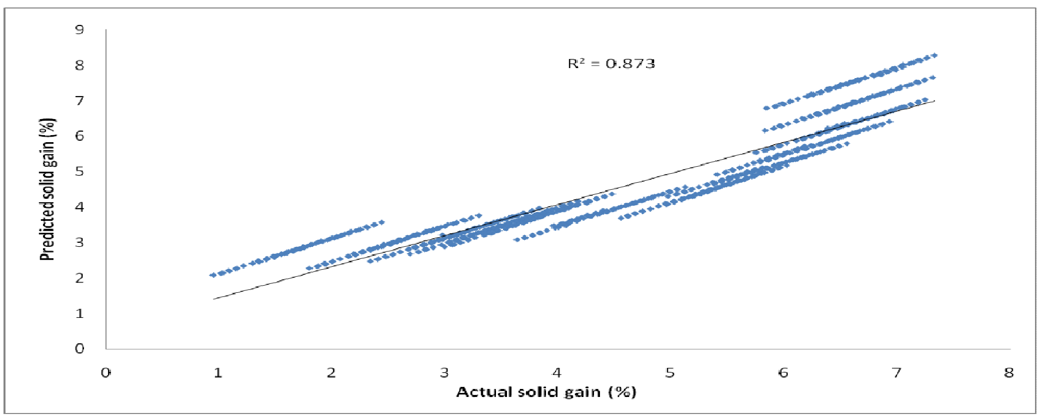

Figure 10: Actual Versus Predicted Solid Gain of Beetroot in Maltodextrin of Validation Sample Set

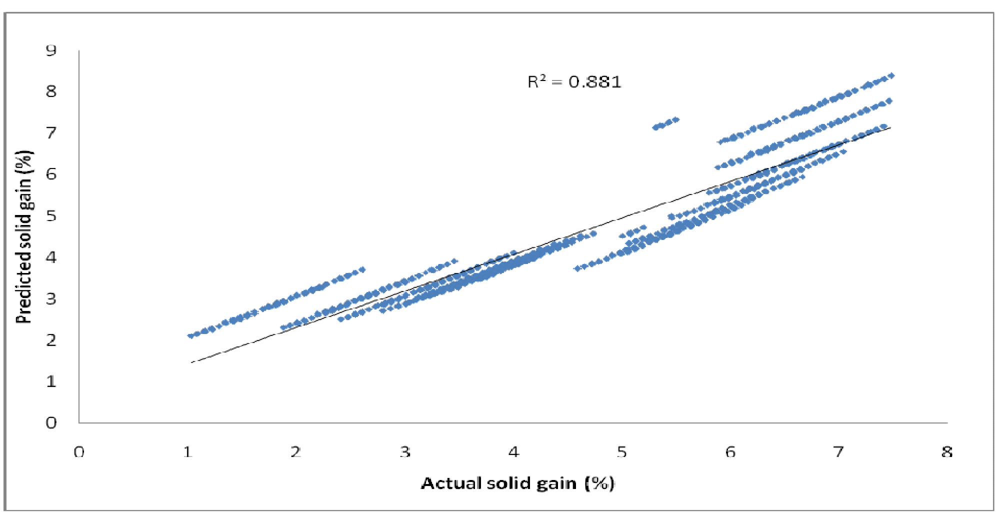

Figure 11: Actual Versus Predicted Solid Gain of Beetroot in Fructose of Calibration Sample Set

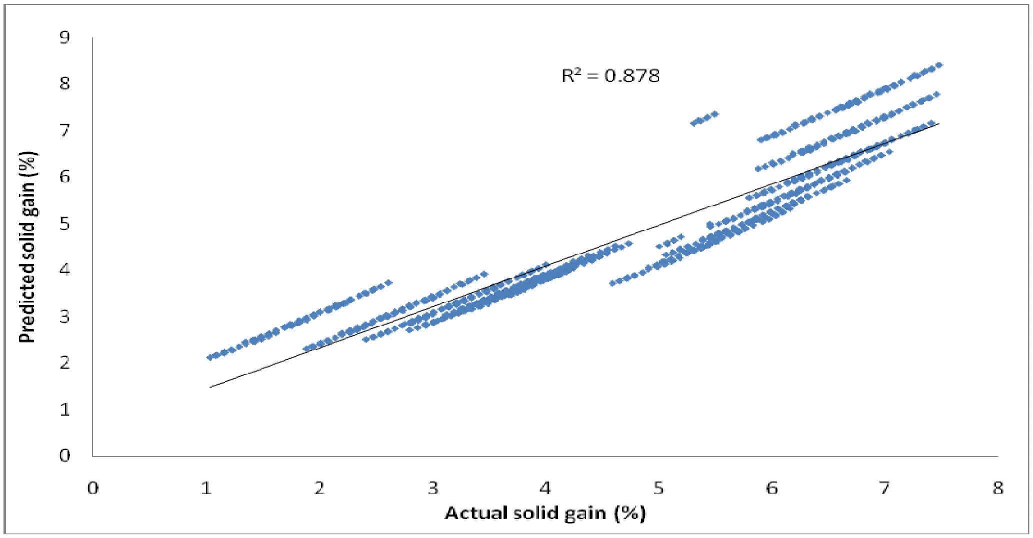

Figure 12: Actual Versus Predicted Solid Gain of Beetroot in Fructose of Validation Sample Set